Development of digital comics as learning media on bacteria

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A R T I C L E I N F O

A B S T R A C T

71% of students of class X IPA SMAN 36 Jakarta,Indonesia have difficulties in studying Biology subjects and 47.2% of students have difficulties in learning topics about bacteria. The research aims to develop digital comics as a medium for learning Biology on bacteria. The research method refers to the research and development model of Borg and Gall (2003). Data was collected with questionnaires to analyze student needs and interviews with Biology teachers in class X IPA. Digital comic was made by Autodesk-SketchBook design application. Product validation was carried out by media and material experts. The product trial consisted of a small group of 12 students, a large group consisting of 46 students, and a biology teacher. The average validation test results obtained a score of 91.69% with a very valid interpretation. The product effectiveness test uses a pre-test and post-test instrument consisting of 30 questions. Analysis of the data obtained an average pre-test score of 70.33 and post-test score was 81.08 with a standard error of 1,432-2.094. The results of the t-test showed a significant value of 0.00 < = 0.05 and the value of t-count < t-table which was -5.847 <2.715, which means the difference is statistically significant or significant at a probability of 0.05. Thus, it can be concluded that there is an effect of using digital comic learning media on bacterial material to improve learning outcomes.

INTRODUCTION

Education is a teaching and learning process that is used to increase knowledge with the main aim of bringing people to good things, so they know what is right and what is wrong (Johan & Harlan, 2014). The process of implementing teaching and learning activities is an important factor so that it can produce qualified future generations of the nation. The learning process has one important component, namely learning media.

All well-designed learning media will greatly help students understand the subject matter to obtain maximum learning outcomes (Utari et al., 2014). Learning media can increase student motivation, prevent student boredom in participating in a learning process and strengthen student understanding and can be used to complement limited facilities and infrastructure (Arina et al., 2014).

Learning media introduced to the world of education underwent various developments in concepts and theories. Several theories of learning media development include the concepts of Dick and Carey, ADDIE, and Borg and Gall. According to Arkün & Akkonyunlu (2008), the ADDIE research and development model in the 1990s was developed by Reiser and Mollenda. The ADDIE model has five stages of development consisting of Analysis, Design, Development, Implementation, Evaluation. The weakness of this research model is that product repair is only done once. Borg & Gall, (1984) model contains basic principles that are characteristic of research and development, namely: researching by studying findings related to the product to be developed, developing products based on previous findings,and conducting field tests on the product. where it will be used later, and make revisions to correct deficiencies found in the field test stages. products that have a high validation value, due to repeated tests, namely initial field tests, main trials, and field tests on the product. The products produced through research and development in the field of education are the development of a learning innovation that is expected to increase educational productivity that is relevant to needs so that it is always updated and encourages a continuous process of innovation.

The development of learning media has grown according to technological developments so that they can be found in various types and formats, with their respective characteristics and advantages. Degeng, (1989) suggests that the types of learning media include visual, audio, and audiovisual. Visual media is media that has elements in the form of images that can be seen, for example, models, actual objects, charts, maps, comics, flashcards, flannel boards, bulletin boards, whiteboards, slides, overhead projectors (Dinata, 2013). Audio media is media in the form of auditive (can only be heard) so that it can stimulate students' thoughts, feelings, and attention to study teaching materials. The types of audio media are sound cassettes, radio programs, and audio CDs. Audio-visual media is a combination of visual and audio media, for example, educational television programs and interactive CDs (Anitah, 2017).

Visual learning media have been introduced thousands of years ago in the form of pictures in caves which are the first historical records and have been communicated and shared with the news. The murals in caves thousands of years ago tell stories of life. From the very beginning, people have felt the specific power of image-based stories. Such tombs in Egypt provide details about the lives of kings and slaves as well as certain depictions, which are described as prehistoric comics. At that time people could not communicate because of the language barrier so they communicated through pictures (Koutníková, 2018). This is in line with the definition that McClaud (1995) has used regarding the broad definition of comics. Comics are intentional sequences that are ordered from one image to another to provide information or an aesthetic experience.

Comics can be used as a medium that bridges the understanding of more complex texts (Kurniawati et al., 2017). Comics can be used as a pedagogical tool for teaching and learning (Tatalovic, 2009). Comics specifically can be used as a science communication tool very well in interestingly conveying scientific concepts. For example, comics are used to teach laboratory safety and ethics (eg Archie: Archie and Friends comics (Battle of Toxic Household Waste) and Let's Have a Blast (Szafran, 1994). Comics as visual teaching aids help a person to enjoy more reading (Svatoš & Maněnová, 2017). The role of comics in education is increasingly being paid attention to in the learning process because it is considered more effective, can increase interest in learning, and is a medium that supports curriculum implementation (Fatimah & Widiyatmoko, 2014). Comics in the field of education are very developing and continuously growing at all levels, as evidenced by the application of comics from elementary to university teaching levels (Green, 2013).

Comics can visualize and simplify learning materials, one of which is Biology. Biology is the study of living things and life. Not a few topics and concepts learned in Biology are abstract or cannot be

explained through direct observation. One of the Biology learning materials that cannot be explained through direct observation is the material about bacteria. According to the results of the study " Problems in learning biology for senior high schools in Lombok Island," most students (74.12%) have difficulty studying bacteria and viruses (Hadiprayitno, Muhlis, & Kusmiyati, 2019). The results of the study also indicated that students had problems studying bacteria and archaea. This difficulty occurs due to the failure of students to understand terminology (such as terms in genetic transfer, namely transformation, transduction, conjugation), understand concepts (characteristics of bacteria and archaea), and write scientific names.

There are two types of comics known to the public, namely printed comics and digital comics (Petersen, 2011). The difference between printed comics and digital comics lies in the comic format used. Print comics are generally in the form of books, while digital comics are comics that are read using electronic media such as computers and gadgets. Digital comics have advantages over printed comics, namely that they are durable and easily accessible without having to buy comics at bookstores (Nurinayati et al., 2018). Digital comics can also overcome boredom, are easier to understand, and are more practical in presenting information and support the implementation of e-learning in schools, namely online learning which is now being carried out in the context of handling COVID-19 by the Indonesian government to keep learning at home (Padma & Sukanesh, 2020).

Digital comics are in great demand by the public, based on the results of a survey from ICv2, (2013), the growth of digital comics sales in the world in 2011 and 2012 reached an increase of 300%. The results of the Milton Griepp survey (2020), sales of digital comics in the COVID-19 era increased from previous years, even subscription-based. Today's digital comic sites are numerous and unlimited in number. In Indonesia, digital comics provider sites include Manga Plus, Crunchyroll, Ciayo Comics, Webtoon, Kakao Page, and others.

Webtoon entered Indonesia in April 2015. The popularity of Webtoon in Indonesia in August 2016 was 6 million active users. Comic publications by Indonesian Webtoon creators in 2017, there are already 65 Webtoon creators. Globally, the webtoon has been downloaded by more than 50 million users on the Google Play Store from all over the world and has grown in various languages such as American-English, Chinese, Japanese, Thai, Indonesian, Spanish, and French (Lestari & Irwansyah, 2020).

The use of digital comics is expected as an alternative learning media that provides a different learning experience so that it can improve learning outcomes because the discussion presented in comics is short and straight to the point. The use of digital comics can be used independently by students and can be used by teachers to support learning, especially biology on bacteria.

The purpose of this research is to produce learning media in the form of digital comics on bacteria material. Learning media can be used as alternative media in carrying out more innovative learning activities so that learning activities can be more effective and efficient. The use of learning media in the form of digital comics on bacteria material can improve student learning outcomes, motivation, and interest. This is supported by the many studies using comics such as at the junior high school level, namely learning comics on ecosystem material by Danaswari et al. (2013), digestive system material by Noning (2018). Then at the high school level learning using comics is used for immune system material by Nurinayati, et al. (2018), metabolic materials by Asmariya et al. (2018), viral material by Ezalia et al. (2020), up to the university level, namely the use of anatomy comics to help medical students by Kim et al. (2012).

METHODS
Research Design
The method used in this study is a research and development method that refers to the formulation of Borg and Gall (2003). This research and development are divided into several stages. The steps involved include preliminary research, planning, product development, product validation, product revision, testing, product improvement, and effectiveness testing.

Population and Samples
The population of this study were students of SMAN 36 Jakarta. Distribution of student needs analysis questionnaires to 62 high school students of class X science. The validation of the instrument on Biology questions on the subject of bacteria was carried out to 65 students of class XI science. The

trial of learning media products in a small group was 12 students of X IPA 1 science class. The test of learning media products in a large group was 46 students of of X IPA 2 and class X IPA 3 science class. Test of effectiveness to 36 students of X IPA 4 science class who were obtained using a simple random sampling technique.

Instrument

The instruments used in this study were a needs analysis questionnaire (biology students and teachers), product validation questionnaires (media experts and material experts), product assessment questionnaires (biology teachers, small groups, and large groups), and evaluation questions (pre-test and post-test) conducted online via Google form. A needs analysis questionnaire (biology students and teachers) was used to obtain initial data and supporting data to see problems in learning bacteria. Product validation questionnaire questionnaires by validators (media experts and material experts) were used to test the initial product validation. Product assessment questionnaire (Biology teachers, small groups, large groups) to determine the responses of teachers and students to learning media on bacteria material. Evaluation questions consist of 30 questions to determine the average value of the pre-test and post-test.

Procedure

The initial stage of the study was data collection by distributing questionnaires and interviews. Questionnaires were distributed to students of class X IPA to analyze student needs regarding aspects of Biology learning, the use of learning media, and the use of gadgets and digital comics. At the interview stage, several questions were asked to the Biology teacher class X IPA regarding Biology learning, the use of media, and learning support facilities. Next, Biology material was analyzed and make product designs to be developed as learning media.

The next stage is to carry out the product validation test stage. Product validation calculations are categorized by using references according to criteria on the descriptive criteria of the percentage of product validation adapted from Utomo, et al., (2020). Product validation tests were carried out by validators, namely media experts and material experts from Jakarta State University lecturers.

The product trial phase was carried out by students (small groups) and Biology teachers for class X IPA SMAN 36 Jakarta, Indonesia. At this stage, the teacher gives a response to the learning media on bacteria material. The trial to the teacher was carried out because the teacher was the user who would teach with the media. Small group test using a sample of 12 students, to find out opinions, assessments, and suggestions from students about the product. The results obtained in the small group test were used for product revision. After the revision, a large group trial was conducted using a sample of 46 students. At this stage, product refinement is also carried out. The effectiveness test was conducted on 36 students using a random sampling technique. The product effectiveness test was conducted to measure the ability of Biology cognitive learning outcomes about bacteria by giving pre-test and post-test questions to students and a t-test (t-test). The measurement of the instrument of cognitive biology learning outcomes about bacteria was carried out by testing the validity and reliability tests. Test the validity of the research instrument using the Pearson product-moment correlation formula. The reliability test used the Kuder-Richardson 21 (KR-21) formula (Arikunto, 2006). The effectiveness test uses a one-group pre-test-post-test research design .

Data Analysis Techniques

This study uses data analysis techniques that include prerequisite tests, hypothesis testing, and effectiveness tests. The steps taken in the data analysis technique are as follows: The first prerequisite test of data analysis includes normality test and homogeneity test. Normality test was performed using the Kolmogorov-Smirnov test (K-S) at a significance level (α) of 0.05. The data can be said to be normally distributed if the significance value (p) is greater than and the data is said to be not normally distributed if the opposite applies. A homogeneity test was conducted to determine whether the distribution of the data obtained was homogeneous or not. In the homogeneity test, Fisher's exact test was used with = 0.05. The data is said to be homogeneous if the significance value (p) is greater than and the data is not homogeneous if the opposite applies.

Hypothesis testing is done by using a statistical analysis t-test (t-test). According to Arikunto, (2006) to analyze the pre-test and post-test one-group design with t-test dependent or Paired Sample t-test.

The following is the research hypothesis: H0: there is no difference between post-test and pre-test scores; H1: there is a difference between the Post-test and Pre-test scores. One-group pre-test-post-test research design as follows.

$$O_1 \ X \ O_2$$

Information:
O_1: Pre-test score, X: The use of digital comic learning media on bacteria materia, lO_2: Post-test score

After that, test the effectiveness using normalized gain. The increase in student cognitive outcomes can be analyzed using the normalized gain index formula (Hake, 1998), namely.

$$\text{Normalized gain} = \frac{(\text{post test score}) - (\text{pre test score})}{(\text{maximum score}) - (\text{pre test score})}$$

The criteria for obtaining the normalized gain index can be seen in Table 1 according to Hake (1998).

Table 1
Normalized Gain Value Criteria

N (Gain)	Description
g > 0.70	Height
0.70 ≥ g ≥ 0.30	Medium
g < 0.30	Low

RESULTS AND DISCUSSION

The results of product validation tests conducted by material experts, media experts, small group and large group students, and Biology teachers are as follows (Table 2).

Table 2
Validation Test Results

Evaluator	Percentage	Interpretation
Material Expert	88.03%	Very valid
Media Expert	90.15%	Very valid
Small group students	90.00%	Very valid
Large group students	90.25%	Very valid
Biology teacher	100.00%	Very valid
Average	**91.69%**	**Very valid**

The product is categorized as very valid based on the average percentage of product validation tests as a learning medium of 91.69% and is expected to increase students' understanding of bacteria. Therefore, a test of the effectiveness of the use of the product was carried out to measure it. The following are the results of the One-Group Pre-test-Post-test Design t-test.

Significant value (2 tailed) is 0.00 < = 0.05. The value of t-count < t-table is -5,847 < 2.715. The t-count value is smaller than the t-table value, so the difference is statistically significant or significant at a probability of 0.05. The magnitude of the difference in the mean of the two groups is shown in the mean difference column, which is -10.75. The mean difference is negative, meaning that the first group (pre-test) has a lower average than the average of the second group (post-test). There is an average difference between the pre-test and post-test. These results indicate that there is an effect of using digital comic learning media on bacteria material.

Table 3
T-Test Results One-Group Pre test- Post test Design

Mean Difference	Std. Deviation	Std Error Mean	95% Confidence Lower	95% Confidence Upper	t-count	df	Sig(2 tailed)
-10.75000	11.03080	1.83847	-14.48229	-7.01771	-5.847	35	.000

Table 4
Normalized Gain Calculation Results

Average Pre Test Score	Average Post Test Score	N-Gain
70.33	81.08	0.3118

The results of the calculation with a gain score of 0.3118 are included in the moderate criteria based on the interpretation of the normalized gain value criteria of Hake, (1998).

Discussion

Based on the results of data collection in the form of a needs analysis questionnaire for class X science students and interviews with Biology teachers at SMAN 36 Jakarta about Biology learning and learning support facilities. The results of the student need analysis questionnaire to show that Biology is quite difficult. The material about bacteria is considered difficult to learn by 47.2% of students. The most use of gadgets to study in a day in the span of 60-90 minutes. Students agree with the innovation of learning media in Biology and many students are interested (91.8%) if learning Biology material is made in the form of digital comics. The results of the interview with the Biology teacher for class X IPA SMAN 36 Jakarta explained that understanding the Biology learning material about bacteria is very important to increase knowledge, students must be able to distinguish bacteria and viruses which have been considered the same. The media used in Biology learning is usually PowerPoint, which according to the Biology teacher, the media is less varied.

The planning stage is done by analyzing the material and making product designs. In analyzing bacterial learning materials based on basic competencies (KD) adapted to content standards and determining indicators of competency achievement and learning objectives. KD for the subject matter of bacteria according to what is listed in the 2013 Revised Edition of the 2013 Curriculum High School Biology Syllabus. Product design is made by creating digital comics using the Autodesk SketchBook design application.

The product validation test phase has an overall average percentage of 91.69% with a very valid interpretation. The assessment of the media validation test obtained an average score of 90.15% with a very valid interpretation. The material validation test obtained a score of 88.03% with a very valid interpretation. Before the small group trial, stage and assessment by the Biology teacher were carried out, revisions and improvements were made first based on notes from media and material expert validators. Media improvements to the text, images, stories, and displays. Improvement of the material by adjusting the material and presentation in learning. Trials by Biology teachers as a whole get an average score of 100%, the interpretation is very valid. The small trial stage obtained an average score of 90% with a very valid interpretation. Morrison, Ross & Kemp (2001) stated that small group tests were used to identify the strengths and weaknesses of the product design being developed to obtain good results before entering the final stage. The large group trial stage obtained an average score of 90.25% with a very valid interpretation. This is because the material presented is clear and systematic, the stories presented are interesting and in accordance with Biology learning, the language is easy to understand. Revisions are made to the presentation of comics, language, benefits, clarity, and suitability of the material so that it becomes more practical in presentation, not boring and the material presented can be easy to understand.

The effectiveness test of the use of the product was measured by statistical testing of the dependent t-test using a one-group pretest-posttest research design. The calculation of the significant value is 0.00 < = 0.05, indicating the average difference between the pre-test and post-test is 10.75. There is an effect of using digital comic learning media on bacterial material to improve learning outcomes. The calculation with the gain score gets a value of 0.3118 which means that it is included in the moderate criteria because the gain value shows 0.70 g = 0.3118 0.30 based on the interpretation of Hake, (1998).

During the emergency period, the spread of Corona Virus Disease or COVID-19, learning is not done face-to-face. Learning is done online. The use of digital comics as a learning medium can motivate student learning because it is not boring, adds to the fun of learning, is easier to understand, is more practical in presenting information, and reduces the limitations of facilities and infrastructure in classroom learning. This is supported by the availability of internet facilities and the amount of time used to learn using gadgets and to support the implementation of e-learning in schools.

CONCLUSION

Based on the results of the research and discussion that has been done, it can be concluded that digital comics learning media on bacteria material can be used as learning media for students of class X IPA SMA. The use of digital comics learning media on bacteria material can improve student learning outcomes as seen from the difference in the average pre-test and post-test. This research is expected to provide benefits to students, namely as an alternative learning media in carrying out learning activities, and teachers as one of the choices of learning media, as well as researchers as a source of reference in further development research.

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